Miniature, Conformal, and Spectrally Agile Ultra Wideband Phased Array Antenna for Communication and Sensing

Completed Technology Project (2013 - 2017)

Project Introduction

Communications, sensing, imaging and navigation functions are integral to NASA's space missions. Central to these functions are Radio Frequency (RF) front ends that are frequency agile, wideband, reconfigurable, very small in size and weight, and of low power (SWAP). Such RF front ends can be used for deep space missions enabling remote reconfiguration and for communications using small satellites such as CubeSats. This project is concerned with the development of small-size, and low power wideband phased arrays (with digital beam forming) for satellites and multi-mission deep space exploration. For the first time, the proposed simple/low-cost phased array will enable on-demand sensing at multiple bands, coupled with adjustable high resolution imaging across various bands. Central to the proposed small wideband array is its unprecedented 20:1 bandwidth. This proposal will build upon this game-changing technology to develop (a) feed networks of equal bandwidth to the phased array, operating at millimeter wavelengths and sub-terahertz frequencies, and (b) low cost beam former technology utilizing on-site encoding to separate signals prior to digitization. This novel on-site coding will allow for a single analog to digital (ADC) or digital to analog converter (DAC) to serve as many as 64 antenna array elements. As such, major reductions in size, complexity and power requirements are envisioned. This is because beam forming and spectral reconfiguration functions are transferred to the processor, implying major agility in the phased arrays functionality for multi-mission operations. Despite their advantages, current phased array systems with associated feed and beam forming electronics have excessive costs, weight, and power consumption, limiting their use for NASA missions. However, recently, a new class of ultra-thin and ultra-wideband arrays were introduced based on the adaptation of emulated anisotropy. By taking advantage of this in-plane anisotropy, for the first time, in-situ ultra wideband apertures and phased arrays were realized. To our knowledge, this technology is the first to overcome the traditional narrowband conundrum for conformal arrays. It is based on the concatenation of novel interweaved antenna elements to realize wideband metamaterials, a concept developed recently under a MURI project at Ohio State that ended in 2009-2010. Currently, no practical phased arrays are available to achieve beam forming and good impedance matching over 20:1 bandwidths. As part of this 4-year research plan, we will develop phased arrays operating from 5 to 100GHz with continuous operation across the entire bandwidth and with minimal reconfiguration, if need be. Among the envisioned features (not mentioned above), the proposed ultra wideband phased array will 1) Provide high gain and large data rates through digital beam forming across a remarkable 20:1 bandwidth, 2) Lead to increased lifetime by replacing bulky satellite dishes with movable parts, 3) Enable spectral agility for imaging and sensing, allowing for trade off between penetration and resolution, 4) Combine sensing and communication functions in a single aperture, and (8) Enable mission adaptability based on changing requirements, and while the satellite or payload is in space. The year to year research plan is as follows: Year 1: The

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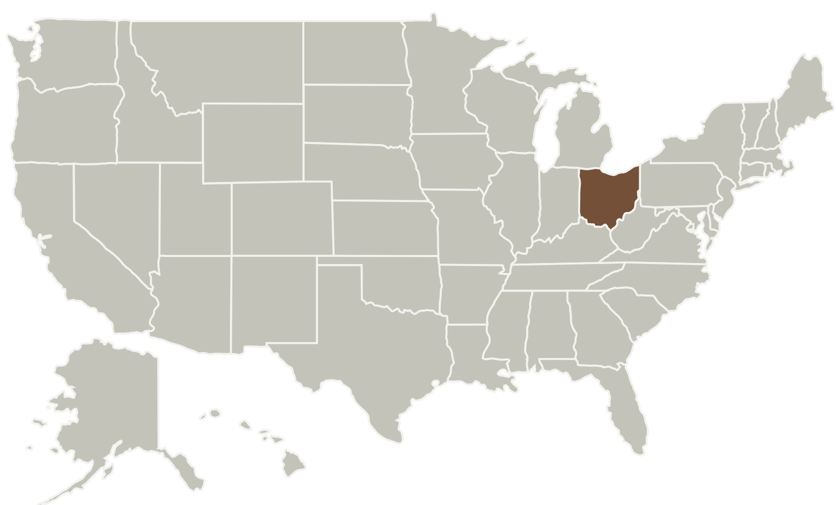
array feed structure and architecture will be resolved, Year 2: Transceiver design will be adapted to reflect commercially available components, Year 3: Aperture and beam former integration with component testing at NASA Glenn (possibly working with Dr. Felix Miranda and Dr. Richard Reinhart), and Year 4: Integrated transceiver testing at NASA Glenn across 5-100GHz, and incorporating NASA's SCaN Testbed and Software Defined Radio (SDR) modules.

Anticipated Benefits

Among the envisioned features (not mentioned above), the proposed ultra wideband phased array will 1) Provide high gain and large data rates through digital beam forming across a remarkable 20:1 bandwidth, 2) Lead to increased lifetime by replacing bulky satellite dishes with movable parts, 3) Enable spectral agility for imaging and sensing, allowing for trade off between penetration and resolution, 4) Combine sensing and communication functions in a single aperture, and (8) Enable mission adaptability based on changing requirements, and while the satellite or payload is in space.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ohio State University-Main Campus	Lead Organization	Academia	Columbus, Ohio

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Ohio State University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

John Volakis

Co-Investigator:

Markus H Novak

Primary U.S. Work Locations

Ohio

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  └ TX05.2 Radio Frequency
    └ TX05.2.6 Innovative Antennas

Target Destination

Earth